Electronic Version
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Claims

[c1] 1) An image generating system, comprising:

a) a light generating means for producing illumination light waves;

b) an array of zone plate modulators for producing modulated light waves, said zone plate modulators comprising:

i) a pair of complementary zone plates;

ii) a modulation means for changing the optical path difference between said pair of complementary zone plates;

whereby said zone plate modulators cause diffractions of said illumination light waves incident thereon with the diffractions modulated by said modulation means, the diffracted portion of said illumination light waves incident upon each of said zone plate modulators is focused into a series of light spots along the axis of each of said zone plate modulators, and the diffracted portion of said illumination light waves incident upon said array of zone plate modulators form a first light spot array on the primary focal plane of said array of zone plate modu-

lators;

c) an illumination means for causing said illumination light waves to be incident upon said array of zone plate modulators;

d) an electronic means for processing pattern data to be presented and for operating said array of zone plate modulators according to the pattern data; and

e) a first receiving surface for receiving said modulated light waves originating from said array of zone plate modulators.

[c2] 2) An image generating system of Claim 1, further comprising a magnifying lens means for providing an image, with a predetermined magnification, of the front surface of said array of zone plate modulators onto said first receiving surface, wherein said magnifying lens means comprises lens elements of a type selected from the group of lens element types consisting of refractive lens elements, diffractive lens elements, and reflective focusing mirrors.

[c3] 3) An image generating system of Claim 2, further comprising a stopping means for blocking one of the diffracted portion and the undiffracted portion of said illumination light waves while allowing the other to propagate to said first receiving surface.

[c4] 4) An image generating system of Claim 1, further comprising:

a) a magnifying lens means for providing an image, with a predetermined magnification, of said first light spot array on the primary focal plane of said array of zone plate modulators onto said first receiving surface as a second light spot array;

b) a stopping means for blocking the undiffracted portion of said illumination light waves and for allowing the diffracted portion of said illumination light waves to pass through;

wherein said magnifying lens means comprises lens elements of a type selected from the group of lens element types consisting of refractive lens elements, diffractive lens elements, and reflective focusing mirrors.

[c5] 5) An image generating system of Claim 4, further comprising a subfield scanning means, cooperative with said electronic means, for scanning the light spots of said second light spot array along a first and a second coplanar dimensions substantially parallel to said first receiving surface to fill in the spaces between the light spots of said second light spot array.

[c6] 6) An image generating system of Claim 1, wherein said first receiving surface is projection screen, further com-

prising a magnifying lens means, whereby said modulated light waves form an image on said projection screen through said magnifying lens means for viewing by a viewer.

[c7] 7) An image generating system of Claim 1, wherein said first receiving surface comprises a movable photoconductive printing medium which moves cooperatively with the operation of said array of zone plate modulators via said electronic means, and said modulated light waves form a latent image on said movable photoconductive printing medium.

[c8] 8) An image generating system of Claim 1, wherein said first receiving surface comprises a movable optical recording medium which moves cooperatively with the operation of said array of zone plate modulators via said electronic means, and said modulated light waves are recorded as data bits arranged in tracks on said movable optical recording medium.

[c9] 9) An image generating system of Claim 1, wherein said first receiving surface comprises a substrate and a movable stage for holding said substrate, wherein said substrate is layered with photosensitive material of which one or more characteristics are modified by said modulated light waves, and said movable stage is substantially

parallel to and is movable coplanar in a first and a second dimensions, and in a third dimension substantially perpendicular to said first and second coplanar dimensions, said movable stage provides three dimensional alignment and positioning of said receiving surface in response to control signals.

[c10] 10) An image generating system of Claim 1, further comprising a digital detecting means and a confocal aperture, wherein said confocal aperture and the primary focal plane of said array of zone plate modulators are substantially confocal, whereby light waves reflected off said receiving surface are converted into electrical signals by said digital detecting means.

[c11] 11) An image generating system of Claim 1, wherein said array of zone plate modulators is a two-dimensional array of zone plate modulators.

[c12] 12) An image generating system of Claim 1, wherein said array of zone plate modulators is an array of zone plate modulators selected from the group consisting of one-dimensional array of zone plate modulators and a staggered two-dimensional array of zone plate modulators, further comprising a second scanning means, whereby said array of zone plate modulators generates a substantially linear image, and said second scanning means

scans the linear image in a direction substantially normal to the linear image to generate a two-dimensional image.

[c13] 13) An image generating system of Claim 1, wherein said zone plate modulators are zone plate modulators selected from the group consisting of reflective zone plate modulators and transmissive zone plate modulators.

[c14] 14) An image generating system of Claim 1, wherein said light generating means provides illumination waves having multiple colors, further comprising a plurality of said arrays of zone plate modulators, wherein said light generating means and said arrays of zone plate modulators operate cooperatively via said electronic means to produce a colored image.

[c15] 15) An image generating system of Claim 1, wherein said light generating means comprises a broadband light source, further comprising a color filtering means and a plurality of arrays of zone plate modulators, wherein said color filtering means separates the lights produced by said broadband light source into lights of multiple colors, and said arrays of zone plate modulators operate cooperatively with said color filtering means via said electronic means to produce a colored image.

[c16] 16) An image generating system of Claim 1, further comprising an optical viewer for monitoring the proper alignment of said first receiving surface.

[c17] 17) A direct viewing system, comprising:

a) a light generating means for producing illumination light waves;

b) an array of zone plate modulators for producing modulated light waves, said zone plate modulators comprising:

i) a pair of complementary zone plates;

ii) a modulation means for changing the optical path difference between said pair of complementary zone plates;

whereby said zone plate modulators cause diffractions of said illumination light waves incident thereon with the diffractions modulated by said modulation means, the diffracted portion of said illumination light waves incident upon each of said zone plate modulators is focused into a series of light spots along the axis of each of said zone plate modulators, and the diffracted portion of said illumination light waves incident upon said array of zone plate modulators form a first light spot array on the primary focal plane of said array of zone plate modulators;

c) an illumination means for causing said illumination light waves to be incident upon said array of zone plate modulators;

d) an electronic means for processing pattern data to be presented and for operating said array of zone plate modulators according to the pattern data; and

e) a magnifying lens means for providing a virtual image using said modulated light waves with a pre-determined magnification, said virtual image being viewable by a viewer through said magnifying lens means.

[c18] 18) A direct viewing of Claim 17, wherein said virtual image is an image of the front surface of said array of zone plate modulators.

[c19] 19) A direct viewing system of Claim 18, further comprising a stopping means for blocking one of the diffracted portion and the undiffracted portion of said illumination light waves while allowing the other to pass through.

[c20] 20) A direct viewing system of Claim 17, wherein said virtual image is an image of said first light spot array on the primary focal plane of said array of zone plate modulators, further comprising a stopping means for blocking the undiffracted portion of said illumination light

waves and allowing the diffracted portion of said illumination light waves to pass through.

[c21] 21) A direct viewing system of Claim 20, further comprising a subfield scanning means, cooperative with said electronic means, for scanning the light spots of said first light spot array along a first and a second coplanar dimensions substantially parallel to the image plane of said virtual image.

[c22] 22) A direct viewing system of Claim 17, wherein said array of zone plate modulators is a two-dimensional array of zone plate modulators.

[c23] 23) A direct viewing system of Claim 17, wherein said array of zone plate modulators is an array of zone plate modulators selected from the group consisting of one-dimensional array of zone plate modulators and a staggered two-dimensional array of zone plate modulators, further comprising a second scanning means, whereby said array of zone plate modulators generates a substantially linear image, and said second scanning means scans the linear image in a direction substantially normal to the linear image to generate a two-dimensional image.

[c24] 24) A direct viewing system of Claim 17, wherein said

zone plate modulators are zone plate modulators selected from the group consisting of reflective zone plate modulators and transmissive zone plate modulators.

[c25] 25) A direct viewing system of Claim 17, wherein said light generating means comprises a broadband light source, further comprising a color filtering means and a plurality of arrays of zone plate modulators, wherein said color filtering means separates the lights produced by the broadband light source into lights of multiple colors, and said arrays of zone plate modulators operate cooperatively with said color filtering means via said electronic means to produce a colored image.

[c26] 26) A direct viewing system of Claim 17, wherein said light generating means provides illumination waves having multiple colors, further comprising a plurality of said arrays of zone plate modulators, wherein said light generating means and said arrays of zone plate modulators operate cooperatively via said electronic means to produce a colored image.

[c27] 27) A maskless lithography system, comprising:

a) a wave source producing illumination waves;

b) an array of zone plate modulators for producing modulated waves, said zone plate modulators comprising:

i) a pair of complementary zone plates;

ii) a modulation means for changing the wave path difference between said pair of complementary zone plates;

whereby said zone plate modulators cause diffractions of said illumination waves incident thereon with the diffractions modulated by said modulation means, the diffracted portion of said illumination waves incident upon each of said zone plate modulators is focused into a series of wave spots along the axis of each of said zone plate modulators, and the diffracted portion of said illumination waves incident upon said array of zone plate modulators form a first wave spot array on the primary focal plane of said array of zone plate modulators;

c) an illumination means for causing said illumination waves to be incident upon said array of zone plate modulators;

d) an electronic means for processing pattern data to be presented and for operating said array of zone plate modulators according to the pattern data; and

e) a first receiving surface for receiving said modulated waves originating from said array of zone plate modulators.

[c28] 28) A maskless lithography system of Claim 27, wherein

said illumination waves are a type of waves selected from the group consisting of electromagnetic waves and matter waves.

[c29] 29) A maskless lithography system of Claim 27, wherein said first receiving surface comprises wave sensitive materials of which one or more characteristics are modified by said modulated waves.

[c30] 30) A maskless lithography system of Claim 27, further comprising a magnifying lens means for providing an image, with a predetermined magnification, of the front surface of said array of zone plate modulators onto said first receiving surface, wherein said magnifying lens means comprises lens elements of a type selected from the group of lens element types consisting of refractive lens elements, diffractive lens elements, and reflective focusing mirrors.

[c31] 31) A maskless lithography system of Claim 30, further comprising a stopping means for blocking one of the diffracted portion and the undiffracted portion of said illumination waves while allowing the other to propagate to said first receiving surface.

[c32] 32) A maskless lithography system of Claim 27, further comprising:

a) a magnifying lens means for providing an image, with a predetermined magnification, of said first wave spot array on the primary focal plane of said array of zone plate modulators onto said first receiving surface as a second wave spot array;
b) a stopping means for blocking the undiffracted portion of said illumination waves and for allowing the diffracted portion of said illumination waves to pass through;
wherein said magnifying lens means comprises lens elements of a type selected from the group of lens element types consisting of refractive lens elements, diffractive lens elements, and reflective focusing mirrors.

[c33] 33) A maskless lithography system of Claim 32, further comprising a subfield scanning means, cooperative with said electronic means, for scanning the wave spots of said second wave spot array along a first and a second coplanar dimensions substantially parallel to said first receiving surface to fill in the spaces between the wave spots of said second wave spot array.

[c34] 34) A maskless lithography system of Claim 27, further comprising a movable stage, cooperative with said electronic means, for holding said first receiving surface, said movable stage being substantially parallel to and

being movable coplanar in a first and a second dimensions, and in a third dimension substantially perpendicular to said first and second coplanar dimensions, said movable stage providing three dimensional alignment and positioning of said first receiving surface in response to control signals.

[c35] 35) A maskless lithography system of Claim 34, further comprising a position detecting means for detecting and correcting positional error caused by said movable stage.

[c36] 36) A maskless lithography system of Claim 27, wherein said first receiving surface comprises a photo-charged particle converter for converting said first wave spot array into a plurality of charged particle beams, further comprising a second receiving surface and a focusing-scanning means, said second receiving surface being layered with charged particle beam sensitive materials for receiving said charged particle beams, said focusing-scanning means focusing said charged particle beams, that originate from said photon-charged particle converter, onto said second receiving surface, and said focusing-scanning means scanning said charged particle beams coplanar in a first and a second dimensions substantially parallel to said second receiving surface.

[c37] 37) A maskless lithography system of Claim 27, wherein

said first receiving surface is a photo-photon converter for converting said first wave spot array into an array of electromagnetic waves having different wavelength.

[c38] 38) A maskless lithography system of Claim 27, further comprising a digital detecting means and a confocal aperture, wherein said confocal aperture and the primary focal plane of said array of zone plate modulators are substantially confocal, whereby light waves reflected off said first receiving surface are converted into electrical signals by said digital detecting means.

[c39] 39) A maskless lithography system of Claim 27, wherein said array of zone plate modulators is a two-dimensional array of zone plate modulators.

[c40] 40) A maskless lithography system of Claim 27, wherein said array of zone plate modulators is an array of zone plate modulators selected from the group consisting of one-dimensional array of zone plate modulators and a staggered two-dimensional array of zone plate modulators, further comprising a second scanning means, whereby said array of zone plate modulators generates a substantially linear image, and said second scanning means scans the linear image in a direction substantially normal to the linear image to generate a two-dimensional image.

[c41] 41) A maskless lithography system of Claim 27, further comprising a higher-order stopping means for blocking higher-order said diffractions except the zeroth and the first order said diffractioins.

[c42] 42) A maskless lithography system of Claim 27, wherein said zone plate modulators are zone plate modulators selected from the group consisting of reflective zone plate modulators and transmissive zone plate modulators.

[c43] 43) A maskless lithography system of Claim 27, further comprising an optical viewer for monitoring the proper alignment of said first receiving surface.

[c44] 44) A maskless lithography system of Claim 27, further comprising a plurality of said array of zone plate modulators.

[c45] 45) A method for generating patterns, comprising:

a) generating illumination waves;

b) providing an array of zone plate modulators for producing modulated waves, said zone plate modulators comprising:

i) a pair of complementary zone plates;

ii) a modulation means for changing the wave path difference between said pair of complementary

zone plates;

whereby said zone plate modulators cause diffractions of said illumination waves incident thereon with the diffractions modulated by said modulation means, the diffracted portion of said illumination waves incident upon each of said zone plate modulators is focused into a series of wave spots along the axis of each of said zone plate modulators, and the diffracted portion of said illumination waves incident upon said array of zone plate modulators form a first wave spot array on the primary focal plane of said array of zone plate modulators;

(c) directing said illumination waves to incident upon said array of zone plate modulators;

(d) processing pattern data to be presented electronically;

(e) operating said array of zone plate modulators electronically according to the pattern data; and

(f) receiving said modulated waves originating from said array of zone plate modulators.

[c46] 46) A method of Claim 45, further comprising separating the undiffracted portion of said illumination waves from the diffracted portion of said illumination waves by blocking one of the diffracted and the undiffracted waves while allowing the other to be received.

[c47] 47) A method of Claim 45, further comprising providing an image of the front surface of said array of zone plate modulators.

[c48] 48) A method of Claim 45, further comprising providing an image of said first wave spot array on the primary focal plane of said array of zone plate modulators, wherein said image is a second wave spot array.

[c49] 49) A method of Claim 48, further comprising scanning the wave spots of said second wave spot array to fill in the spaces around the wave spots of said second wave spot array along a first and a second coplanar dimensions.

[c50] 50) A method of Claim 45, further comprising providing a first receiving surface for receiving said modulated waves, and acquiring a confocal image of said first receiving surface by arranging an aperture and the primary focal plane of said array of zone plate modulators at a substantially confocal configuration.

[c51] 51) A method of Claim 45, wherein said array of zone plate modulators in step (b) is an array of zone plate modulators selected from the group consisting of reflective zone plate modulators and transmissive zone plate modulators.

[c52] 52) A method of Claim 45, wherein said array of zone plate modulators in step (b) comprises a two-dimensional array of zone plate modulators.

[c53] 53) A method of Claim 45, wherein said array of zone plate modulators in step (b) comprises an array of zone plate modulators selected from the group consisting of one-dimensional array of zone plate modulators and a staggered two-dimensional array of zone plate modulators for generating substantially linear images, further comprising scanning said linear images in a direction substantially normal to said linear images to form a two-dimensional image.

[c54] 54) A method of Claim 45, further comprising converting said modulated light waves originating from said array of zone plate modulators into a second array of waves of a type selected from the group consisting of charged particle beams and electromagnetic waves.

[c55] 55) A method of Claim 45, further comprising providing a plurality of arrays of zone plate modulators, wherein the illumination waves in step (a) comprise colored illumination light waves to illuminate said arrays of zone plate modulators for providing a colored image viewable by a viewer.

[c56] 56) A method of Claim 45, further comprising providing a first receiving surface for receiving said modulated waves, and monitoring the proper alignment of said first receiving surface through an optical viewer.